C. F. Dixon

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MINES BRANCH

OTTAWA

PHYSICAL METALLURGY DIVISION

TEST REPORT PM-65-31

METALLOGRAPHIC EXAMINATION AND X-RAY ANALYSES OF TWO URANIUM ALLOYS

By

C. Dixon

Nuclear and Powder Metallurgy Section

October 1st , 1965

PHYSICAL METALLURGY DIVISION
TEST REPORT PM-65-31

To: Canadian Armament Research and Development Establishment
P.O. Box 1427
Quebec, P.Q.

Re: Metallographic Examination and X-ray Analyses of Two Uranium Alloys

Attn: Dr. H.P. Tardif, Head,
Metallurgical Section

INTRODUCTION

Four uranium alloy samples were received from Dr. H.P. Tardif on July 22/65 for metallographic examination and X-ray analyses. The samples were marked 37-#1, 37-#2, 44-#1 and 44-#2 and the alloy composition and heat treated conditions are shown in Table 1.

TABLE 1

Sample	Alloy Composition	H.T. Condition
37-#1	U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V	W.Q. from 815°C (1500°F)
37-#2	U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V	W.Q. from 815°C (1500°F) and aged for 20 min at 425°C (800°F)
44-#1	U-1 wt % Mo-0.5 wt % Zr-0.5 wt % Nb-0.5 wt % V	W.Q. from 815°C (1500°F)
44-#2	U-1 wt % Mo-0.5 wt % Zr-0.5 wt % Nb-0.5 wt % V	W.Q. from 815°C (1500°F) and aged for 2 min at 425°C (800°F)

The hardnesses for the 37-#1, 37-#2, 44-#1 and 44-#2 samples were indicated to be Rc 14-15, Rc 54-55, Rc 41-42 and Rc 56.5 respectively.

PROCEDURE AND RESULTS

The four samples were rough polished on silicon carbide abrasive papers up to a 600 grit, followed by polishing for 2 to 3 minutes on a silk cloth using Linde A as the abrasive with plenty of water. The samples were then electropolished at 40 volts for up to 1 minute in a solution containing 4 parts acetic acid and 1 part of a solution of 118g of chromium troxide in 100 cc of distilled water. A water-cooled stainless steel container was used as the cathode and the temperature of the electrolyte was kept below 25°C (80°F).

Figures 1 to 4 are photomicrographs of samples 37-#1, 37-#2, 44-#1, and 44-#2 respectively, in the as-polished condition and at 100 magnifications.

In both alloys there were considerable amounts of inclusions, which were more numerous in the aged samples. This is more noticeable in the U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V alloy and can be seen by comparing the photomicrographs in Figure 1 (37-#1, water quenched from 815°C, 1500°F) and Figure 2 (37-#2, water quenched from 815°C, 1500°F and aged for 20 minutes at 425°C, 800°F).

The microstructures of these samples, unlike many uranium alloys, were not visible under polarized light and it was not possible to reveal the grain structures by normal electrolytic or chemical etching, or heat tinting techniques. However it was possible to cathodically etch the samples by ion bombardment. The samples were bombarded with medium energy argon ions (8 KeV) at a current density of 5 mA/cm^2 for 1 hr and the pressure in the bombardment chamber was 0.1 micron.

The etched structures of samples 37-#1, 37-#2, 44-#1 and 44-#2 are shown in the photomicrographs in Figures 5 to 8 respectively and it is evident that samples 37-#1 and 37-#2 (Figures 5 and 6) have a smaller grain size than samples 44-#1 and 44-#2 (Figures 7 and 8)

X-ray diffraction analyses were carried out on all the samples. The structures of the 37-#2, 44-#1 and 44-#2 were identified as consisting of the alpha phase but there was no information available in the literature to identify the X-ray diffraction pattern obtained from the 37-#1 sample.

DISCUSSION

Because the amount of inclusions in both uranium alloys increased on ageing, it would appear that some of the alloying constituents are held in solid solution on quenching from 815°C (1500°F) and precipitated during ageing at 425°C (800°F). It is also evident from the etched structures that the precipitates were not predominantly at the grain boundaries.

The smaller grain size of the samples 37-#1 and 37-#2 which had a higher alloying content was possibly due to the grain refining effect of some of the additional constituents particularly zirconium.

The X-ray diffraction analyses show that a phase change occurred in the U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V alloy during ageing. From the low hardness value (Rc 14-15) of the as-quenched structure in sample 37-#1 it would appear that a considerable amount of the gamma phase was retained during quenching (although this could not be confirmed by X-ray analysis) and this transformed to the alpha phase on ageing.

CONCLUSIONS

1. Some of the constituents in both alloys appeared to be held in solution on quenching from 815°C (1500°F) and precipitated after ageing for 20 minutes at 425°C (800°F).

2. The grain structure of none of the samples could be revealed by normal etching techniques, but it was possible to cathodically etch the samples by ion bombardment.

3. The structures of the samples 37-#2 44-#1 and 44-#2 were in the alpha phase.

4. The X-ray diffraction pattern of the structure of sample 37-#1 could not be identified but the hardness value (Rc 14-15) suggested it consisted mainly of the gamma phase.

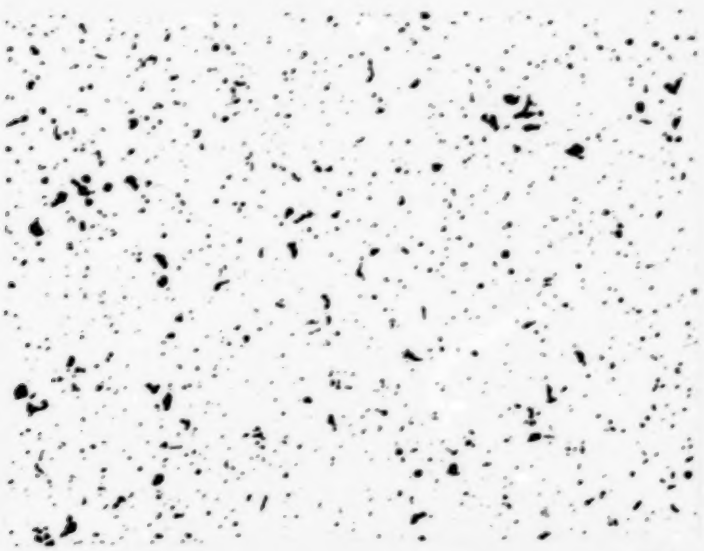
5. The U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V alloy transformed from an unidentified phase (presumed to be gamma) in the sample quenched from 815°C (1500°F) to the alpha phase after ageing for 20 minutes at 425°c (800°F).

ACKNOWLEDGEMENTS

Thanks are due to Dr. R. Cunningham and Miss J Mg-Yelim for cathodic bombardment etching of the samples.

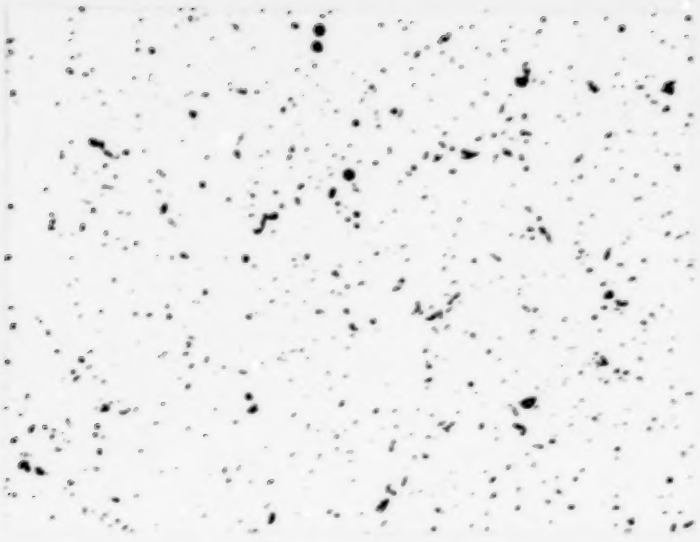
100X

Figure 1. U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V
37-#1, Water Quenched from 815°C (1500°F)
Electropolished



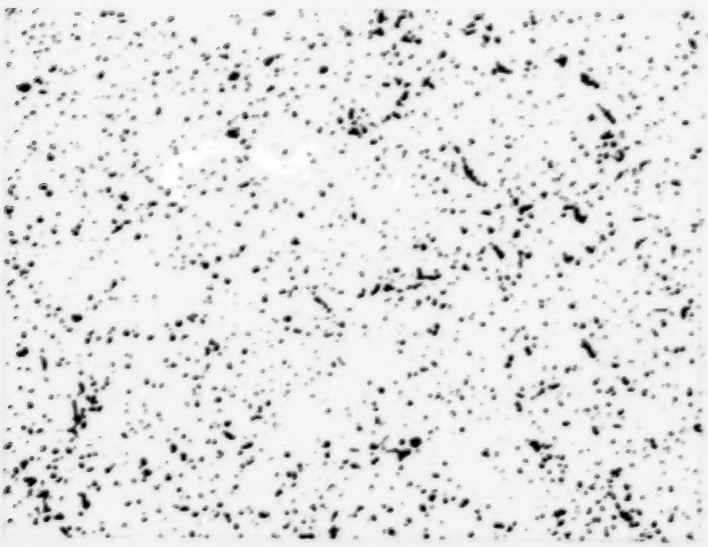
100X

Figure 2. U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V
37-#2, Water Quenched from 815°C (1500°F)
Aged 20 min. at 425°C (800°F) Electropolished



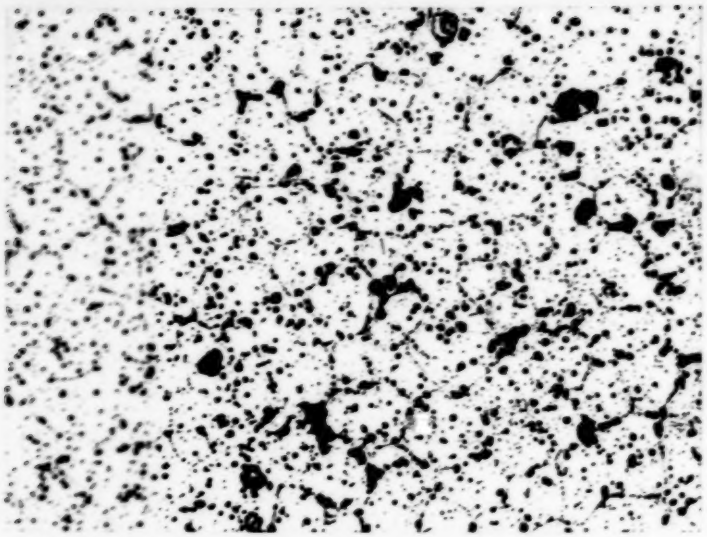
100X

Figure 3. U-1 wt % Mo-0.5 wt % Zr-0.5 wt % Nb-0.5 wt % V 44-#1, Water Quenched from 815°C (1500°F) Electropolished



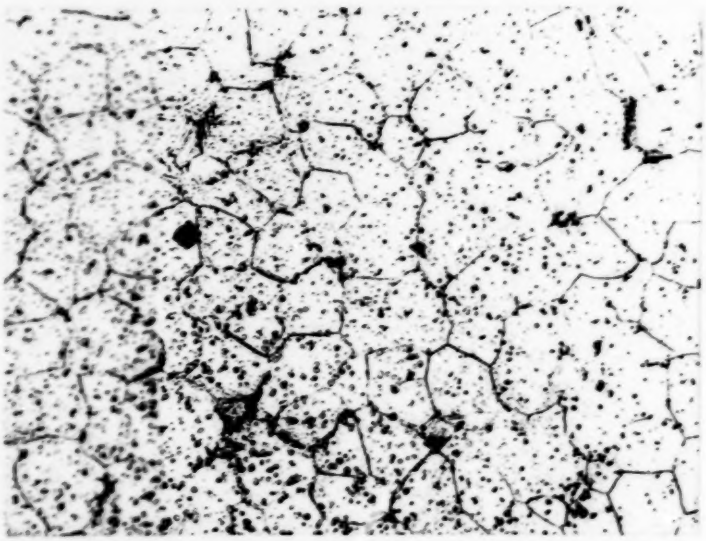
100X

Figure 4. U-1 wt % Mo-0.5 wt % Zr-0.5 wt % Nb-0.5 wt % V 44-#2 Water Quenched from 815°C (1500°F) Aged 20 min. at 425°C (800°F) Electropolished



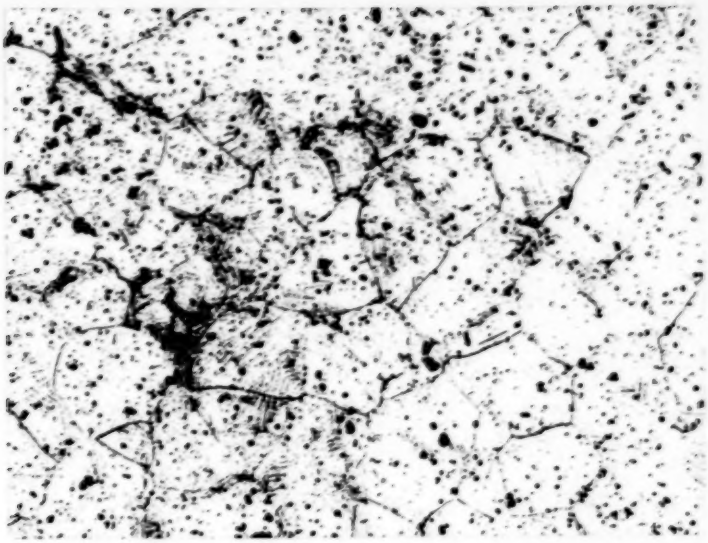
100X

Figure 5 U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V 37-#1 Water Quenched from 815°C (1500°F) Cathodic etch.



100X

Figure 6 U-2 wt % Mo-1 wt % Zr-1 wt % Nb-1 wt % V 37-#2 Water Quenched from 815°C (1500°F) Aged 20 min at 425°C (800°F) Cathodic etch.



100X

Figure 7. U-1 wt % Mo-0.5 wt % Zr-0.5 wt % Nb-0.5 wt % V 44-#1 Water Quenched from 815°C (1500°F) Cathodic Etch.

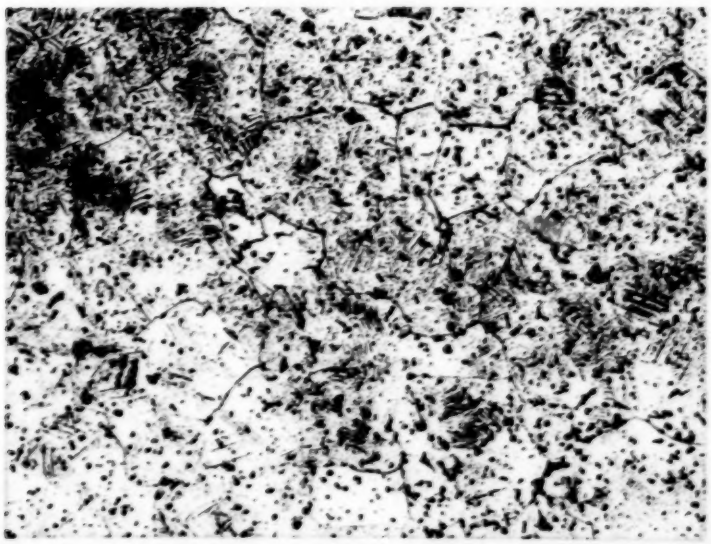


Figure 8. U-1 wt % Mo-0.5 wt % Zr 0.5 wt % Nb-0.5 wt % V 44-#2 Water Quenched from 815°C (1500°F) Aged 20 min at 425°C (800°F) Cathodic Etch.